

## ENERGY PRODUCING SYSTEMS

# FOSSIL FUELS

### INTRODUCTION

Fossil fuels have played a critical role in the development of our modern society. Prior to the start of the industrial age (200 to 300 years ago) we met the vast majority of our energy needs with renewable resources such as wood for heat, watermills for grinding crops or wind to propel sailing vessels. With the advent of fossil fuels such as oil, gas and coal we found new sources of energy that have been pivotal in the establishment of industrialized economies. Our modern transportation systems are almost entirely dependent on the use of petroleum (oil). Modern society has been fundamentally shaped by the use of fossil fuels and we are still very much dependent on these fuels for our energy needs.

Fossil fuels are essentially the remains of ancient organisms; predominately plants and bacteria. This organic matter resulted from ancient forests and swamps that existed on earth from 100 million to 400 million years ago. Following changes in the earth's climate and geology a portion of this material was trapped (*sequestered*) below the earth's surface under multiple layers of sediment and rock. This sequestered organic matter was exposed to immense heat and pressure from the earth's interior for millions of years. This process physically changed the original decaying biomass and created the fossil fuels we use today. Oil, gas and coal deposits can be found in specific geological sediments throughout the world.

When we burn gasoline in our cars or use oil for heating needs we are in essence burning ancient plants. The chemical process is called combustion and burning fossil fuels is the equivalent



Source: NREL

of burning a piece of firewood from a tree that existed several million years ago. However, the deposits of fossil fuels such as oil, gas and coal are not infinite. Some sources of fossil fuels are already becoming more difficult to obtain and we will eventually deplete the available reserves of these fuels. In addition to simply running out, there are increasing environmental problems associated with our current use of fossil fuels. Finding other forms of energy to replace our disappearing fossil fuels is becoming increasingly critical.

## CATEGORIES OF FOSSIL FUELS

### COAL

Coal has been used to power steamships and railroad engines, heat homes and provide heat for steel production since the 1800s. Coal is the most abundant of the fossil fuels. Coal can be found in several forms. For example some is hard, black, shiny and rock-like with a high-energy content



Source: D. Parsons, NREL

(anthracite), while other deposits are soft and crumbly with a reduced energy content (lignite). Currently, 24 percent of the world's energy needs are met with coal. The primary use for coal is in the generation of electrical power. Coal is also used for industrial applications such as steel production. Coal represents an increasingly dominant energy source for developing countries such as China and India. More than half

the electricity generated in the United States comes from combusting coal and 84 percent of electrical power generated in Missouri is achieved using coal-fired plants.

The United States has abundant coal reserves with coal present in 38 states. Currently, the leading coal producing states are Wyoming, Kentucky, West Virginia, Pennsylvania and Texas. Almost all the coal mined in the United States is combusted to generate electrical power. A major factor in the mining of coal is the sulfur content of the coal. High sulfur content in coal can significantly increase air pollutants associated with its combustion.

Missouri does have coal reserves; however, the high sulfur content of Missouri coal limits its use as an energy source.

Worldwide the percentage of coal used for energy is expected to decline slightly as coal-fired systems are being replaced by cleaner burning natural gas systems. However, declines in coal use by Western Europe, Eastern Europe and Russia are expected to be more than offset by increases in coal consumption in the United States, Japan and developing Asia.

Coal has more environmental impact than any other energy source. When coal is combusted large amounts of air pollutants are produced. The main emissions from coal are sulfur dioxides, nitrogen oxides, air particulates, carbon dioxide and mercury. Sulfur dioxide and nitrogen oxide emissions have been linked to acid rain. Mercury is a toxic heavy metal that has been linked to various neurological and reproductive impairments. Under current regulatory guidelines power plants in the United States can emit as much 50 tons of mercury annually. Combustion of coal also produces large quantities of carbon dioxide, which is one of the leading causes of global warming. The Midwest relies heavily on coal for power production. With its higher population, Missouri produces 2-3 times as much carbon dioxide than the surrounding states of Iowa, Kansas, Nebraska, North Dakota, South Dakota and Arkansas.

## **PETROLEUM**

Petroleum is a thick, viscous and flammable black liquid that has been used for lighting since ancient times. Petroleum can be refined and separated into different components (fractions) and are used to generate products such as gasoline, propane gas, various lubricating oils and asphalt. Petroleum is also a key ingredient in plastics and many other common



Source: Acurex Environmental

household products. Petroleum is the leading source of energy worldwide. Over forty percent of total energy consumed is derived from petroleum products such as gasoline, diesel fuel, propane gas, and domestic cooking and heating fuels. The majority of the petroleum used goes towards transportation needs.

The first automobile was produced in 1892 and by 1920 there were 9 million cars in the United States. Today there are more than 160 million vehicles on the road. Although the United States is the second leading producer of petroleum, we import more petroleum than any other country, consuming 17 million barrels of oil per day. This makes the United States dependent on the major petroleum exporting countries of Saudi Arabia, Russia, Norway, Venezuela, Iran, the United Arab Emirates, Iraq, Kuwait, Nigeria and Mexico.

Petroleum is refined into gasoline for cars, jet fuel for planes and diesel fuel for trucks. Transportation systems are a significant source of air pollution producing sulfur dioxide, nitrogen oxides and carbon dioxide emissions. Nitrogen oxides contribute to the formation of ozone and the subsequent formation of smog. Automobiles are a major contributor to urban air quality issues. Petroleum products also present environmental concerns during extraction, transportation and use. Used motor oil lost from automobiles onto paved surfaces or following improper disposal represents a major source of surface water pollution.

## **NATURAL GAS**

Natural gas can often be found in locations where petroleum is extracted. Natural gas is primarily composed of methane with varying amounts of other hydrocarbons such as ethane, propane, and butane. The United States is the world's largest producer and consumer of natural gas. Over 20 percent of U.S. energy needs are met using natural gas systems. More than half the homes in America use natural gas for residential heating needs. Natural gas is one of the fastest growing sources of energy worldwide.

Natural gas produces less air pollution than coal or petroleum. Most combustion engines can be modified to use natural gas. In an attempt to reduce air pollution many large U.S. cities have initiated programs to promote the use of natural gas for large car fleets, city trash trucks and municipal transportation buses. Natural gas operated vehicles can reduce the production of carbon monoxide and other air pollutants by as much as 60 to 80 percent.



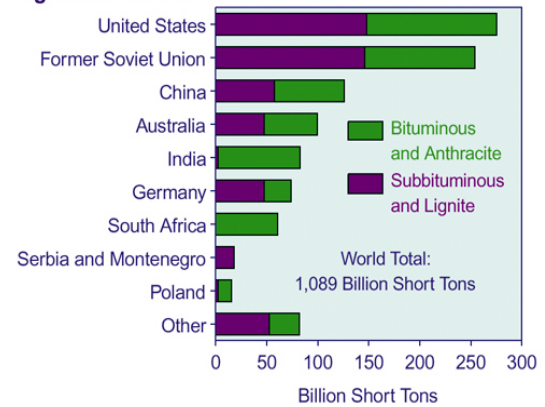
## RESERVES OF FOSSIL FUELS

Coal is the most abundant fossil fuel. Coal reserves worldwide vary significantly in quality and accessibility. Bituminous and anthracite coal beds produce much higher energy fuels than subbituminous and lignite coal reserves. The table to the right indicates the reserves of these coal types worldwide. Australia, the United States and Canada have some of the best-developed reserves of high quality coal and produce approximately 85 percent of the coal traded.

North American coal beds are widely distributed (see map right). Not all of these coal beds are currently mined due to the high sulfur content in some locations. Missouri coal is not used to any significant degree due to sulfur content of the local coal beds. Efforts to research methods for removing sulfur from coal are being pursued. It is estimated that with the current rate of consumption, assuming no net growth in overall coal use, that the United States has enough coal to last 100 to 200 years.

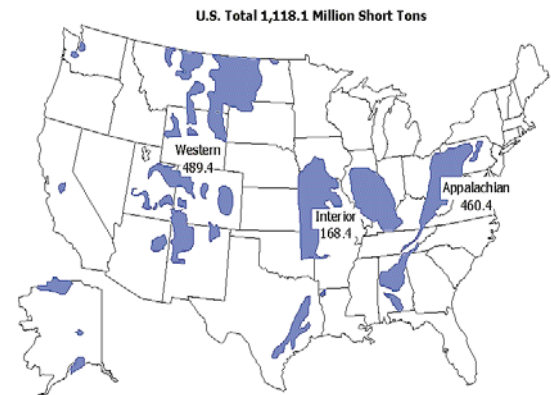
Petroleum reserves have a different distribution than coal. The largest oil fields are located in the Middle East representing more than 60 percent of the known world petroleum reserves. The top petroleum exporting countries are Saudi Arabia, Russia, Norway, Venezuela, Iran, United Arab Emirates, Iraq, Kuwait, Nigeria and Mexico. Even though the United States is a major producer of

**Figure 55. World Recoverable Coal Reserves**



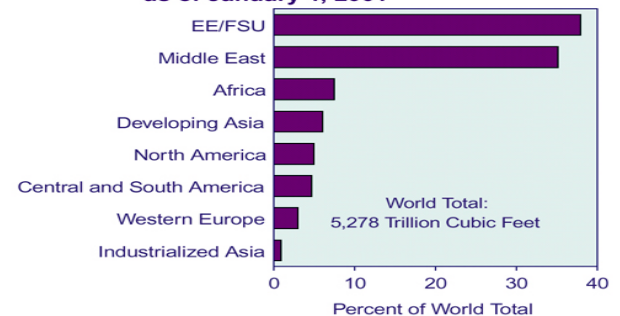
Note: Data represent recoverable coal reserves as of January 1, 1999.

Source: Energy Information Administration, *International Energy Annual 1999*, DOE/EIA-0219(99) (Washington, DC, January 2001), Table 8.2.



Source: EIA

**Figure 41. World Natural Gas Reserves by Region as of January 1, 2001**



Source: "Worldwide Look at Reserves and Production," *Oil & Gas Journal*, Vol. 98, No. 51 (December 18, 2000), pp. 121-124.

EE/FSU: Eastern Europe and the Former Soviet Union

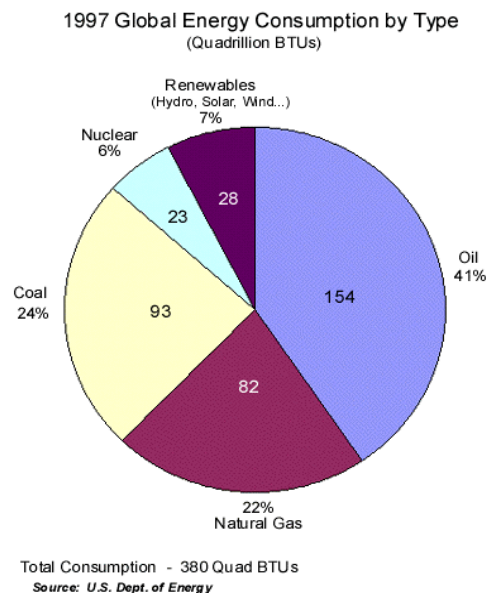
petroleum, we consume most of the oil we produce. In fact the United States is the largest single importer of oil in the world, and more than half the petroleum consumed in the United States comes from foreign sources.

Texas is the largest producer of domestic petroleum followed by Alaska and California. The largest single oil field in the U.S. is located in Prudhoe Bay, Alaska. While the state of Missouri does produce some petroleum, the amount is less than 0.02 percent of the output of the state of Texas alone.

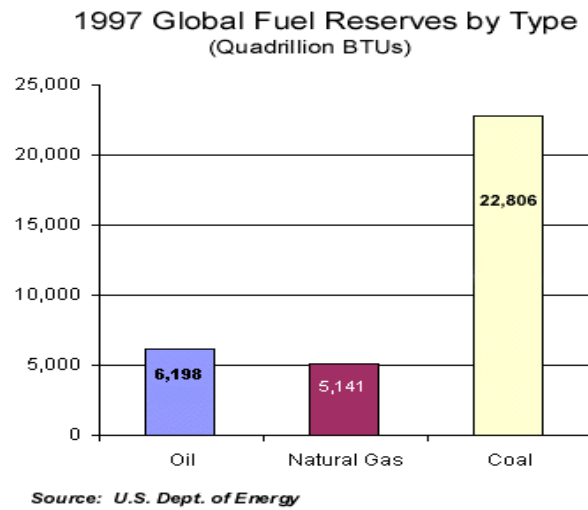
Known natural gas reserves have grown in the last 20 years with the discovery of major resources in Russia, the Middle East, and South and Central America. World natural gas reserves are more widely distributed than petroleum fields. The largest natural gas reserves are found in Eastern Europe and the former Soviet Union.

## SPECIFIC CHARACTERISTICS OF FOSSIL FUELS

The majority of the world's energy needs are currently being met by the use of fossil fuels. Fossil fuels have proven to be an abundant source of energy and have been critical in the development of our modern world. However fossil fuels use also raises serious environmental issues. Acid rain is caused by sulfur oxides and nitrogen oxides released into the air predominately by coal-fired power plants. Acid rain has been shown to have significant impacts on aquatic and forest ecosystems. Nitrogen oxides contribute to ozone pollution and have been linked to serious health issues and long term health problems. Mercury emissions from coal-fired power plants are starting to become an increasing health concern. Fossil fuel use has contributed to a rise in atmospheric levels of carbon dioxide raising global climate change concerns. The mining, extraction and transportation of fossil fuels can cause various types of environmental damage ranging from habitat loss to pollution and contamination of ecosystems. Used motor oil from automobiles has become a significant surface water pollutant in the United States.



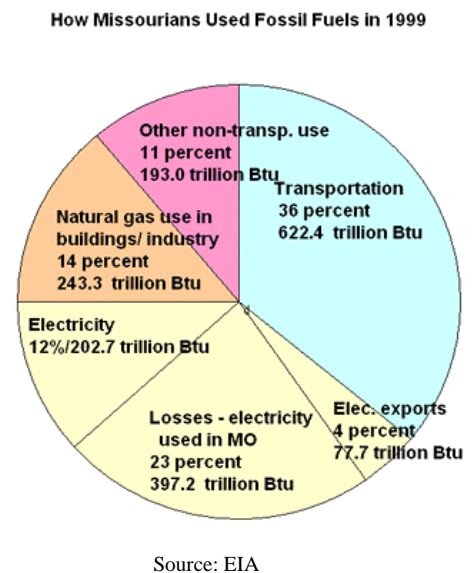
Fossil fuels are a limited resource. The supplies of fossil fuels will not last forever. The average American household consumes 400 million British Thermal Units (BTU) of energy per year. Each BTU is approximately equal to the amount of energy produced by burning a single match. Given the current consumption levels, fossil fuels will become increasingly scarce in the next 100 years.



The world will not only require energy in the future, but those energy needs are destined to grow. Development of renewable energy systems such as hydroelectric, geothermal, wind, biomass and solar will become more critical. We will have to find other sources of power, as we will most certainly eventually run out of fossil fuels.

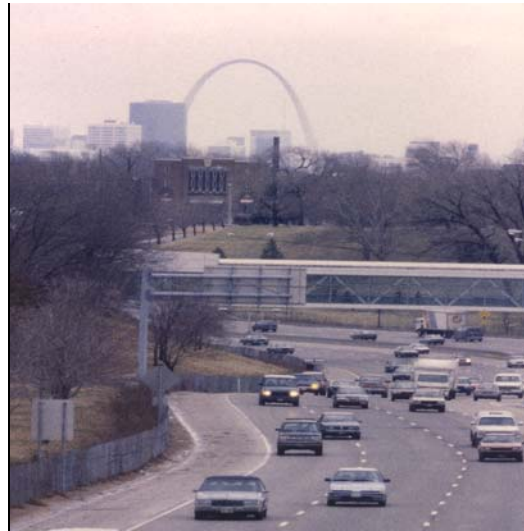
## THE FUTURE OF FOSSIL FUELS IN MISSOURI

The majority of Missouri energy needs are met using fossil fuels. We import the petroleum we use to propel our transportation systems and the coal and natural gas used to generate our electricity. While the fossil fuels we use for power may be brought into the state, the pollution produced from these energy sources effect people right here. Both Kansas City and St. Louis are having serious problems with air quality as a result of automobile traffic, industry and utility emissions. Coal-fired electric plants produce significant amounts of mercury (a highly toxic heavy metal). Currently, Missouri ranks 11<sup>th</sup> in the



country in total power plant emissions of mercury. Statewide fish consumption advisories have recently been issued as a result of mercury contamination. Missouri generates double the levels of carbon dioxide, nitrogen oxides and sulfur oxides as many of the less populated surrounding states. Missouri ranks as one of the top 10 states in the United States concerning the production of nitrogen oxides

Missouri does not produce the fossil fuels it uses to any significant degree. Missouri has fairly large coal deposits, but the sulfur content of the coal currently prevents any significant resource development. Missouri spent more than \$635 million importing coal in 1997, and more than 30 percent of the states total energy budget was spent on imported transportation fuels. If even a small fraction of this money could be spent on locally produced renewable energy sources, such as solar power, biomass systems, hydropower or wind power, the benefit to Missouri's economy and environment could be significant.



**AIR POLLUTION FROM COAL IN ST. LOUIS MISSOURI**

*The gentleman posed during the day for the picture on the left, when coal use in the city was unregulated and again on the right following a ban limiting residential and commercial coal use.*

*Note: The street lights where on during daylight hours as a result of coal smoke.*

